



IMPROVING FIFTH-GRADE STUDENTS' MATHEMATICS LEARNING OUTCOMES IN ANGLE CONCEPTS USING THE STAD COOPERATIVE LEARNING MODEL ASSISTED BY POLYPAD

Rozita Salma Qurratuaini, Sri Muryaningsih

Elementary School Teacher Education Study Program, Faculty of Teacher Training and Education,
Universitas Muhammadiyah Purwokerto, Indonesia

Corresponding author email: rozitasq@gmail.com, srimuryaningsihump@gmail.com

Abstract

Learning angle concepts remains challenging for many elementary school students because mathematics instruction is still dominated by teacher explanations, leaving students with limited opportunities to actively construct their own understanding. Consequently, abstract mathematical concepts are often not fully understood. This research sought to enhance fifth graders' mathematical understanding of angles by introducing them to the Student Teams Achievement Division (STAD) cooperative learning approach, which is supported by Polypad media. Classroom Action Research (CAR) was used in the research, which was carried out in two cycles, according to the paradigm proposed by Kemmis and McTaggart. Data were collected through achievement tests, classroom observations, and documentation, then analyzed using descriptive quantitative techniques supported by descriptive qualitative analysis. The findings showed improvements across all domains of learning outcomes. Cognitive learning mastery increased from 55.56% in Cycle I to 83.33% in Cycle II. Likewise, affective learning mastery improved from 72.22% to 100%, while psychomotor learning mastery rose from 44.44% to 94.44%. Overall, integrating the STAD cooperative learning model with Polypad created a more participatory learning environment, which contributed to improving students' mathematics learning outcomes on angle concepts.

Keywords: Angle Material; Elementary School; Mathematics Learning Outcomes; PolyPad

Abstrak

Pembelajaran matematika pada materi sudut masih menjadi tantangan bagi sebagian siswa sekolah dasar karena proses belajar lebih banyak didominasi oleh penjelasan guru dibandingkan dengan keterlibatan aktif siswa dalam membangun pemahamannya sendiri. Kondisi tersebut menyebabkan konsep-konsep yang bersifat abstrak belum dipahami secara optimal. Dengan memanfaatkan media Polypad, proyek ini bertujuan untuk meningkatkan pemahaman matematis siswa kelas lima mengenai sudut melalui penerapan pendekatan pembelajaran kooperatif STAD. PTK, sebuah pendekatan penelitian dua siklus berdasarkan model Kemmis dan McTaggart, digunakan dalam penelitian ini. Data penelitian diperoleh dari tes, pengamatan, dan catatan, kemudian dianalisis melalui teknik deskriptif kuantitatif serta didukung oleh analisis deskriptif kualitatif. Temuan ini memperlihatkan adanya peningkatan pada seluruh ranah hasil belajar. Ranah kognitif meningkat dari 55,56% pada Siklus I menjadi 83,33% pada Siklus II. Pada ranah afektif, persentase ketuntasan bertambah dari 72,22% menjadi 100%, sedangkan pada ranah psikomotor meningkat dari 44,44% menjadi 94,44%. Secara keseluruhan, pelaksanaan model STAD yang dipadukan dengan media Polypad mampu memberikan pengalaman belajar yang lebih partisipatif sehingga berkontribusi terhadap meningkatnya hasil belajar matematika siswa pada materi sudut.

Kata kunci: Hasil Belajar Matematika; Materi Sudut; Polypad; Sekolah Dasar

INTRODUCTION

Logical, systematic, and critical thinking, as well as problem-solving skills, are essential competencies developed through mathematics education. Therefore, mathematics plays a fundamental role in elementary education. Mathematics instruction is intended not only to equip students with computational skills but also to help them develop conceptual understanding that can be applied in various real-life situations. Accordingly, learning activities should be designed in accordance with

elementary students' cognitive development so that they can construct meaningful understanding of mathematical concepts that cannot be directly observed (Susanto, 2016; Heruman, 2017).

Despite its importance, mathematics instruction in elementary schools continues to face various challenges, particularly in geometry learning. The topic of angles requires students to visualize geometric objects, measure angle magnitudes, and connect abstract concepts with concrete representations. However, classroom instruction remains predominantly teacher-centered, where students receive information passively rather than actively construct knowledge through meaningful learning experiences. Consequently, many students experience difficulties distinguishing types of angles, accurately measuring angle sizes, and constructing angles correctly using measuring instruments, resulting in unsatisfactory learning outcomes (Heruman, 2017; Susanto, 2016).

The preliminary classroom observations conducted in Grade V of SD Negeri 2 Gumiwang indicated that most students had not achieved the Minimum Learning Achievement Criteria (KKTP) for the topic of angles. The identified problems were not limited to conceptual understanding but also included low student participation during instruction and inadequate skills in using protractors correctly. Furthermore, teacher-centered instructional practices restricted student interaction, while instructional media capable of supporting the visualization of geometric concepts were rarely utilized. These conditions highlight the need for an instructional approach that actively engages students while facilitating concrete understanding of angle concepts.

One promising instructional approach is the Student Teams Achievement Division (STAD) cooperative learning model. In this model, students with diverse academic backgrounds work collaboratively to achieve common learning goals through guided discussion and peer assistance (Slavin, 2015). Previous studies have consistently demonstrated that the STAD model effectively improves mathematics learning outcomes, student participation, and collaborative skills among elementary school students (Hoziyana & Muryaningsih, 2023; Suardiana, 2021; Arafah et al., 2024). However, these studies primarily focused on the effectiveness of STAD as an instructional strategy without integrating digital manipulative media capable of enhancing the visualization of geometric concepts.

Recent advances in educational technology have introduced interactive digital learning media such as PolyPad, which enables students to explore geometric concepts through virtual manipulatives. Ahmad and Siller (2024) and Genç (2023) reported that virtual manipulatives facilitate students' conceptual understanding of mathematics while increasing learning engagement. Similarly, Amelia et al. (2025) and Novitasari et al. (2025) found that PolyPad effectively supports geometry instruction by improving concept visualization and promoting active student participation. Nevertheless, these studies mainly examined the effectiveness of PolyPad as a learning medium, whereas the integration of PolyPad within the instructional procedures of the STAD cooperative learning model has received limited attention.

A review of previous studies reveals that research on STAD has primarily emphasized the instructional model, whereas studies on PolyPad have focused mainly on the use of digital learning media. Few studies have systematically integrated both approaches within a Classroom Action Research framework aimed not only at improving students' cognitive achievement but also at fostering their affective and psychomotor development in learning angle concepts. Moreover, the effectiveness of STAD and PolyPad has generally been investigated independently. The novelty of the present study lies in integrating the STAD cooperative learning model with PolyPad to support angle instruction and evaluating improvements in students' cognitive, affective, and psychomotor learning outcomes through two cycles of Classroom Action Research. This integrated approach is expected to provide empirical

evidence regarding an effective mathematics instructional strategy that enhances not only conceptual understanding but also students' learning attitudes and practical skills in a comprehensive manner.

Based on the foregoing discussion, this study aims to examine whether the implementation of the Student Teams Achievement Division (STAD) cooperative learning model assisted by PolyPad improves Grade V students' mathematics learning outcomes on the topic of angles at SD Negeri 2 Gumiwang.

METHOD

This study employed Classroom Action Research (CAR) based on the model proposed by Kemmis and McTaggart, which consists of four stages: planning, action, observation, and reflection (Arikunto et al., 2015). The study was conducted at SD Negeri 2 Gumiwang, Purwonegoro District, Banjarnegara Regency, Central Java, Indonesia, during the second semester of the 2025/2026 academic year. The participants were 18 fifth-grade students, comprising 8 girls and 10 boys. This class was selected because the preliminary observation revealed that students' learning outcomes on the topic of angles had not yet met the Minimum Learning Achievement Criteria (KKTP).

During the planning stage, the researchers prepared lesson modules, assessment instruments, student observation sheets, PolyPad learning media, and student worksheets (LKPD). In Cycle I, the instructional activities focused on the concepts of angles, types of angles, and identifying angles in objects found in students' surroundings. At the end of Cycle I, reflection was conducted to identify areas for improvement and to design the instructional interventions implemented in Cycle II. In Cycle II, the learning activities emphasized measuring angles using a protractor and constructing angles of specified measures with the assistance of PolyPad. The instructional process followed the syntax of the Student Teams Achievement Division (STAD) cooperative learning model, including teacher presentation, team study, individual quizzes, individual improvement scores, and group recognition (Slavin, 2015).

Data on students' cognitive learning outcomes were collected through achievement tests, whereas affective and psychomotor outcomes were assessed through classroom observations conducted throughout the instructional process. The cognitive test instrument was developed based on the learning outcome indicators for the topic of angles and aligned with the instructional objectives. The affective observation instrument assessed students' participation, collaboration, responsibility, and self-confidence. Meanwhile, the psychomotor observation instrument evaluated students' skills in using a protractor, measuring angles, constructing angles, and utilizing PolyPad during learning activities. Classroom observations were conducted collaboratively by the classroom teacher and a university student acting as observers using standardized observation rubrics.

The cognitive learning outcome data were analyzed using descriptive quantitative techniques by calculating the class mean score using the following formula (Sudjana, 2016):

$$\bar{X} = \frac{\sum X}{N}$$

The notation used in the formula is defined as follows:

$\bar{X}$ = class mean score
 $\sum X$ = total score of all students
 N = total number of students

The percentage of students achieving learning mastery was calculated using the following formula (Purwanto, 2013):

$$P = \frac{n}{N} \times 100\%$$

The notation used in the formula is defined as follows:

P = percentage of students achieving the Minimum Learning Achievement Criteria (KKTP)
 n = number of students achieving the Minimum Learning Achievement Criteria (KKTP)
 N = total number of students

Data obtained through classroom observations, photographs, and researchers' field notes were analyzed using descriptive qualitative analysis to provide a comprehensive description of the instructional process, teacher and student activities, and the changes that occurred throughout each research cycle. The findings from each cycle served as the basis for reflection in determining improvements to be implemented in the subsequent cycle. The intervention was considered successful when at least 80% of the students achieved the Minimum Learning Achievement Criteria (KKTP) score of 75 in the cognitive domain, accompanied by continuous improvement in the affective and psychomotor domains across each research cycle.

RESULTS AND DISCUSSION

Cognitive Learning Outcomes

Following the implementation of the STAD cooperative learning model assisted by PolyPad, students' cognitive learning outcomes in geometry improved. The improvement was evidenced by increases in both the class mean score and the percentage of students achieving learning mastery across each research cycle.

Table 1. Summary of Students' Cognitive Learning Outcomes

Indicator	Cycle I	Cycle II
Class mean score	72,22	83,61
Number of students achieving learning mastery	10	15
Learning mastery percentage	55,56%	83,33%

As shown in Table 1, students' cognitive learning outcomes improved across the two research cycles. The class score increased from 72.22 in Cycle I to 83.61 in Cycle II, representing an improvement of 11.39 points. The number of students achieving learning mastery also increased from 10 students (55.56%) in Cycle I to 15 students (83.33%) in Cycle II. This result met the study's success criterion, which required at least 80% of the students to achieve the Minimum Learning Achievement Criteria (KKTP) score of 75. Figure 1 illustrates the improvement in students' cognitive learning outcomes across the two research cycles.

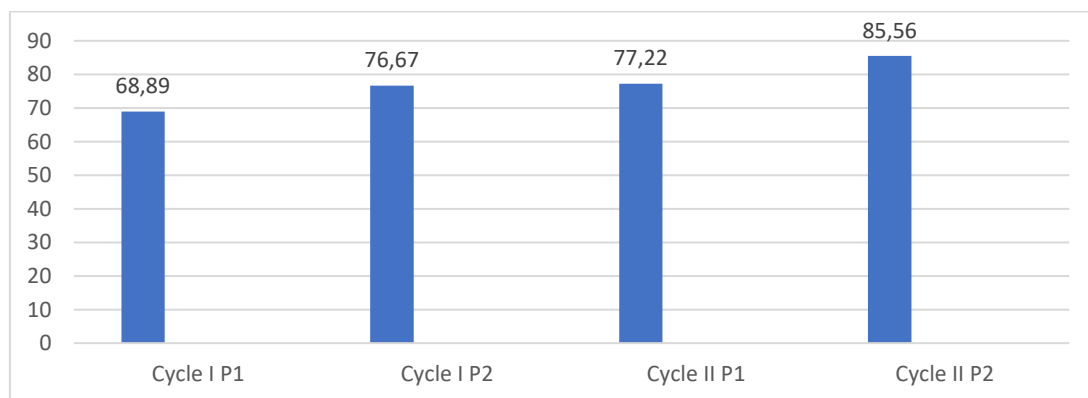


Figure 1. Improvement in Students' Cognitive Learning Outcomes Across Learning Sessions

Based on Figure 1, students' cognitive learning outcomes showed a consistent upward trend across the learning sessions. In Cycle I, the class mean score increased from 68.89 in the first meeting to 76.67 in the second meeting. This improvement continued in Cycle II, with the mean score increasing from 77.22 in the first meeting to 85.56 in the second meeting. The improvement in Cycle I was 7.78 points, while the increase in Cycle II reached 8.34 points. Although the improvement at the beginning of Cycle II was relatively modest, the average score remained higher than that achieved at the end of Cycle I. These findings indicate that the instructional improvements implemented following the reflection phase of Cycle I had a positive impact on students' conceptual understanding, although they still required time to adapt to the learning strategy.

The reflection conducted after Cycle I revealed that several students experienced difficulties in using PolyPad, were not yet accustomed to participating actively in group discussions, and encountered problems in measuring and constructing angles accurately. Therefore, several improvements were implemented in Cycle II, including more systematic demonstrations of how to use PolyPad, reinforcement of angle concepts through more varied examples, optimization of heterogeneous group formation, and more intensive teacher guidance during group discussions. These improvements resulted in greater student engagement throughout the learning process, enabling the class to achieve a learning mastery rate of 83.33% by the end of Cycle II.

The improvement in students' cognitive learning outcomes suggests that the Student Teams Achievement Division (STAD) cooperative learning model, when integrated with PolyPad, effectively facilitated students' understanding of angle concepts. According to Slavin (2015), the effectiveness of STAD is supported by three essential components: positive interdependence, in which group members work together to achieve shared learning goals; individual accountability, whereby each student remains responsible for their own learning through individual quizzes; and peer tutoring, which allows students with stronger conceptual understanding to assist classmates who encounter learning difficulties. These components encourage students to participate actively in discussions, exchange ideas, and collaboratively construct conceptual understanding, ultimately contributing to improved learning outcomes (Sartania et al., 2022; Huri et al., 2024).

In addition to the instructional model, the use of PolyPad also played an important role in enhancing students' understanding of angle concepts (Putra et al., 2025). PolyPad enables students to visualize angles, measure them interactively, and receive immediate feedback while exploring mathematical ideas (Putra et al., 2025; Xu, 2025). These findings are consistent with Piaget's theory (1926), which emphasizes that concrete experiences form the foundation for elementary students' understanding of abstract concepts. Likewise, Bruner (1961) argued that visual representation plays a crucial role in developing mathematical understanding. Consequently, the use of PolyPad made the abstract concept of angles more accessible by presenting it through interactive visualizations and hands-on learning activities (Cruz & Viseu, 2026).

The findings of this study are consistent with previous research demonstrating that the implementation of the STAD cooperative learning model improves elementary students' mathematics learning outcomes (Hoziyana & Muryaningsih, 2023; Suardiana, 2021). They also support earlier studies reporting that PolyPad enhances students' understanding of geometric concepts by providing interactive visualizations that facilitate independent conceptual construction (Amelia et al., 2025; Novitasari et al., 2025). Unlike previous studies, however, the present research integrated the STAD cooperative learning model and PolyPad within a single instructional framework on the topic of angles through Classroom Action Research. This integration not only improved students' conceptual mastery but also promoted collaborative, interactive, and student-centred learning, enabling the study to achieve its predetermined success criteria.

Affective Learning Outcomes

Following the implementation of the Student Teams Achievement Division (STAD) cooperative learning model assisted by PolyPad, students' affective learning outcomes in learning angle concepts improved. The improvement was evidenced by increases in both the mean affective score and the percentage of students who achieved the expected level of affective performance across the research cycles.

Table 2. Summary of Students' Affective Learning Outcomes

Indicator	Cycle I	Cycle II
Class mean score	2,72	3,58
Number of Students Achieving the Expected Affective Performance	13	18
Percentage of Students Achieving the Expected Affective Performance	72,22%	100%
Criteria	Good	Very Good

As shown in Table 2, students' affective learning outcomes improved across the two research cycles. The mean affective score increased from 2.72 in Cycle I to 3.58 in Cycle II, representing an improvement of 0.86 points. The percentage of students achieving the expected level of affective performance also increased from 72.22% (13 students) in Cycle I to 100% (18 students) in Cycle II, indicating that all students met the established assessment criteria for the affective domain. These findings demonstrate that the success criterion for the affective domain was fully achieved. Figure 2 illustrates the improvement in students' affective learning outcomes across the learning sessions.

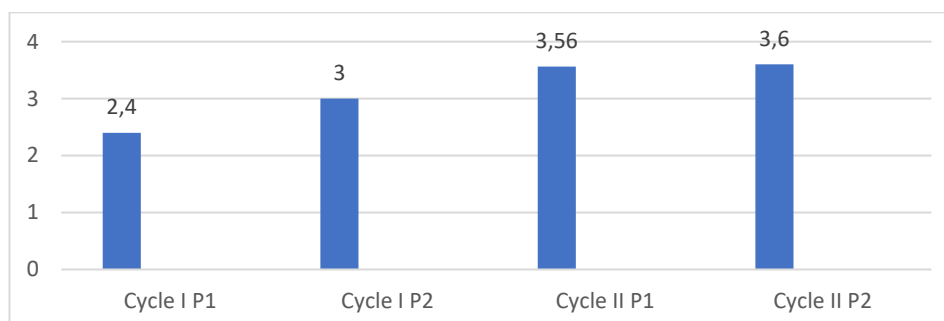


Figure 2. Improvement in Students' Affective Learning Outcomes Across Learning Sessions

As illustrated in Figure 2, the mean affective learning score showed consistent improvement across the learning sessions. In Cycle I, the mean score increased from 2.40 in the first meeting to 3.00 in the second meeting. In Cycle II, the mean score further increased from 3.56 in the first meeting to 3.60 in the second meeting. These findings indicate that students' affective learning outcomes improved consistently because of the instructional refinements implemented throughout the research cycles.

The reflection conducted after Cycle I revealed that some students participated less actively in group discussions. In addition, their ability to express ideas and their sense of responsibility in completing group tasks had not yet developed optimally. Therefore, several improvements were introduced in Cycle II, including clearer task assignments, increased learning motivation, reinforcement of the importance of collaboration among group members, and more intensive teacher guidance during group activities. Furthermore, PolyPad was used more strategically to encourage the active participation of all group members. These improvements enhanced students' engagement, self-confidence,

collaboration, and responsibility, enabling all students to meet the established assessment criteria for the affective domain by the end of Cycle II.

The improvement in the affective domain demonstrates that integrating the Student Teams Achievement Division (STAD) cooperative learning model with PolyPad positively influenced students' learning attitudes. Collaborative activities in heterogeneous groups encouraged students to respect one another's opinions, work together to complete assigned tasks, and take responsibility for both individual and group success. At the same time, the use of PolyPad increased students' enthusiasm for learning by allowing them to actively explore angle concepts through interactive learning activities. Consequently, the learning process became more engaging, fostering greater self-confidence and encouraging students to ask questions, express their ideas, and participate actively in classroom discussions.

The findings of this study are consistent with previous research reporting that the implementation of the STAD cooperative learning model improves students' learning activities, motivation, collaboration, and positive attitudes in mathematics learning (Arafah et al., 2024; Octavia, 2022; Sahmat & Dhoruri, 2024). Unlike previous studies, which primarily focused on enhancing learning activities or motivation, the present study demonstrates that integrating the STAD model with PolyPad not only increased students' engagement during mathematics instruction but also fostered self-confidence, responsibility, collaboration, and active participation comprehensively, resulting in all students meeting the established assessment criteria for the affective domain.

Psychomotor Learning Outcomes

Following the implementation of the Student Teams Achievement Division (STAD) cooperative learning model assisted by PolyPad, students' psychomotor learning outcomes in learning angle concepts improved. The improvement was evidenced by increases in both the mean psychomotor score and the percentage of students who achieved the expected level of psychomotor performance across the research cycles.

Table 3. Summary of Students' Psychomotor Learning Outcomes

Indicator	Cycle I	Cycle II
Class Mean Score	2,43	3,50
Number of Students Achieving the Expected Level of Psychomotor Performance	8	17
Percentage of Students Achieving the Expected Level of Psychomotor Performance	44,44%	94,44%
Criteria	Fair	Very Good

As shown in Table 3, the class mean score for the psychomotor domain increased from 2.43 in Cycle I to 3.50 in Cycle II, representing an improvement of 1.07 points. The percentage of students achieving the expected level of psychomotor performance also increased from 44.44% (8 students) in Cycle I to 94.44% (17 students) in Cycle II. These findings indicate that the study's success criterion for the psychomotor domain was achieved, as most students demonstrated a very good level of proficiency in using measuring instruments and learning media. Figure 3 illustrates the improvement in students' psychomotor learning outcomes across the learning sessions.

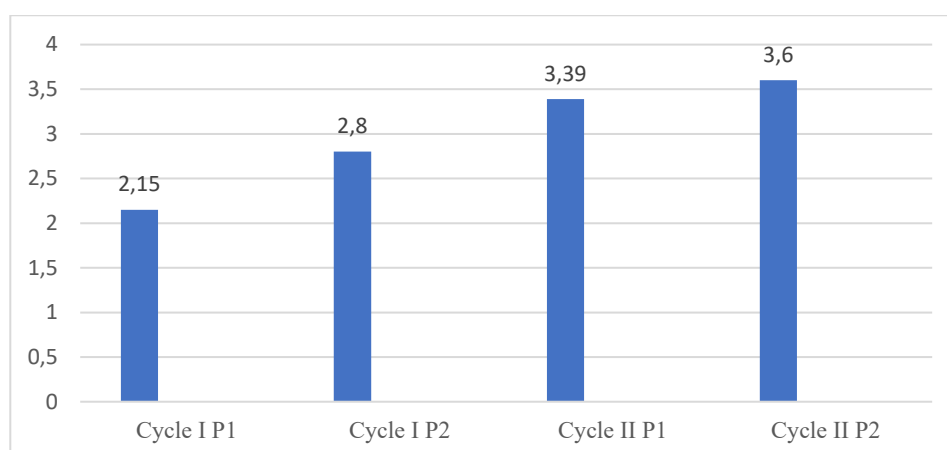


Figure 3. Improvement in Students' Psychomotor Learning Outcomes Across Learning Sessions

As illustrated in Figure 3, students' psychomotor learning outcomes improved progressively across the learning sessions. In Cycle I, the mean psychomotor score increased from 2.15 in the first meeting to 2.80 in the second meeting. The improvement continued in Cycle II, with the mean score increasing from 3.39 at the first meeting to 3.63 at the second. These findings indicate that students' skills in measuring angles, constructing angles, and using PolyPad developed consistently following the instructional improvements implemented in each research cycle (Cruz & Viseu, 2026).

The reflection conducted after Cycle I revealed that several students still experienced difficulties in using a protractor accurately, constructing angles with specified measurements, and independently utilizing the features available in PolyPad. Based on these findings, several instructional improvements were implemented in Cycle II, including more systematic demonstrations of how to use both the protractor and PolyPad, clearer step-by-step practical examples, and more intensive teacher guidance during hands-on activities. These improvements enhanced students' skills in measuring angles, constructing angles, and using PolyPad, resulting in 94.44% of the students achieving the expected level of psychomotor performance by the end of Cycle II.

The findings in the psychomotor domain demonstrate that the implementation of the Student Teams Achievement Division (STAD) cooperative learning model assisted by PolyPad effectively promoted students' practical skills through active participation in the learning process (Rahmad, 2025). During group activities, students not only discussed angle concepts but also practiced measuring and constructing angles while providing constructive feedback on their peers' work (DeJarnette, 2022). These collaborative activities enabled students to develop greater proficiency in using measuring instruments and increased their confidence in completing practical tasks (Okolie et al., 2022).

Furthermore, the use of PolyPad enabled students to explore angle concepts through interactive visualization and manipulation of geometric objects (Putra et al., 2025). This process allowed students to compare measurement results, correct errors immediately, and gain more concrete learning experiences. By combining hands-on practice with digital visualization, the instructional approach helped students develop practical skills in applying mathematical concepts rather than merely understanding them at a theoretical level (Cirneanu & Moldoveanu, 2024; Tessema et al., 2024). The findings of this study are consistent with previous research demonstrating that virtual manipulatives enhance students' mathematical skills through interactive exploration and visualization activities (Ahmad & Siller, 2024; Amelia et al., 2025; Novitasari et al., 2025). Likewise, the implementation of the STAD cooperative learning model provides opportunities for students to support one another, engage in collaborative discussions, and practice together, thereby promoting the development of

practical skills (Hoziyana & Muryaningsih, 2023; Suardiana, 2021). Unlike previous studies, which primarily examined the effectiveness of either the instructional model or the learning media independently, the present study demonstrates that integrating the STAD cooperative learning model with PolyPad in teaching angle concepts effectively improved students' psychomotor skills progressively until the predetermined success criteria were achieved.

CONCLUSION

The implementation of the Student Teams Achievement Division (STAD) cooperative learning model assisted by PolyPad effectively improved fifth-grade students' understanding of angle concepts at SD Negeri 2 Gumiwang. The improvement was evident across all measured learning domains. In the cognitive domain, the class mean score increased significantly from 72.22 in Cycle I to 83.61 in Cycle II. In contrast, the percentage of students achieving learning mastery increased from 55.56% to 83.33%, meeting the study's success criterion that at least 80% of the students achieve the Minimum Learning Achievement Criteria (KKTP) with a minimum score of 75. In the affective domain, the mean score improved from 2.72 to 3.58, accompanied by an increase in the percentage of students achieving the expected level of affective performance from 72.22% to 100%. Similarly, in the psychomotor domain, the mean score increased from 2.43 to 3.50, while the percentage of students achieving the expected level of psychomotor performance rose from 44.44% to 94.44%. These findings indicate that the STAD cooperative learning model, when integrated with PolyPad, provides an effective alternative approach to mathematics instruction by promoting a more concrete, active, and collaborative understanding of angle concepts. The integration of cooperative learning and interactive digital media not only enhances students' conceptual understanding but also fosters the development of positive learning attitudes and practical skills.

REFERENCES

- Ahmad, S., & Siller, H. S. (2024). Investigating the effect of manipulatives on mathematics achievement: The role of concrete and virtual manipulatives for diverse achievement level groups. *Journal on Mathematics Education*, 15(3), 979–1002. <https://doi.org/10.22342/jme.v15i3.pp979-1002>
- Amelia, I., Rhut Nugraheni, E., Dahlia, I., Sariningsih, R., & Prajabatan PGSD IKIP Siliwangi, P. (2025). Analisis Motivasi Belajar Siswa Kelas V SDN Cibabat Mandiri 2 pada Materi Sudut dalam Mata Pelajaran Matematika dengan Bantuan Media Polypad. *PENDAS: Jurnal Ilmiah Pendidikan Dasar*, 10, 466–474. <https://doi.org/10.23969/jp.v10i02.27138>
- Arafah, F. N., Sumarno, S., Rahayu, L. P., & Untari, M. F. A. (2024). Analisis Aktivitas Belajar Matematika Siswa pada Model Kooperatif Tipe Student Teams Achievement Division (STAD) di Sekolah Dasar. *Ainara Journal (Jurnal Penelitian Dan PKM Bidang Ilmu Pendidikan)*, 5(4), 475-483. DOI: <https://doi.org/10.54371/ainj.v5i4.632>
- Arikunto, S., Suhardjono, & Supardi. (2015). *Penelitian tindakan kelas (Edisi revisi)*. Jakarta: Bumi Aksara
- Bruner, J. S. (1961). *The Act of Discovery*. In *In Search of Pedagogy Volume I*. USA: Harvard Educational Review.
- Cirneanu, A. L., & Moldoveanu, C. E. (2024). Use of digital technology in integrated mathematics education. *Applied System Innovation*, 7(4), 66. <https://doi.org/10.3390/asi7040066>

- Cruz, S., & Viseu, F. (2026). AI-supported hybrid learning in exploratory geometry: For higher education. *European Journal of Science and Mathematics Education*, 14(3), 471-488. <https://doi.org/10.30935/scimath/18798>
- DeJarnette, A. F. (2022). What do correct answers reveal? The interpersonal and mathematical aspects of students' interactions during groupwork in seventh grade mathematics. *Journal of the learning sciences*, 31(4-5), 509-544. <https://doi.org/10.1080/10508406.2022.2073232>
- GENÇ, G. (2023). Matematik Öğretiminde WEB 2.0 Aracı (Polypad) Uygulaması Örneği. *Cumhuriyet International Journal of Education*, 13, 226–241. <https://doi.org/10.30703/cije.1287302>
- Heruman. (2017). *Model pembelajaran matematika di sekolah dasar*. Bandung: PT Remaja Rosdakarya.
- Hoziyana, G., & Muryaningsih, S. (2023). Penerapan Model Pembelajaran Kooperatif Tipe STAD untuk Meningkatkan Hasil Belajar Matematika Di Kelas V SD Negeri 1 Windunegara, Kabupaten Banyumas. *Cendekiawan*, 5(1), 8–21. <https://doi.org/10.35438/cendekiawan.v5i1.271>
- Huri, A. S., Sahae, J. P., Prince, A. M., & Srivastava, R. (2024). Collaborative learning communities: Enhancing student engagement and academic achievement. *Educational Administration: Theory and Practice*, 30(5), 7031-7036. Doi: 10.53555/kuey.v30i5.3624
- Muryaningsih, S. (2020). Peningkatan sikap rasa ingin tahu dan prestasi belajar matematika melalui model pembelajaran matematika realistik. *CENDEKIAWAN*, 2(1), 1–12. <https://doi.org/10.35438/cendekiawan.v2i1.166>
- Novitasari, Charisma, D., & Ameliawati. (2025). Upaya Peningkatan Hasil Belajar Peserta Didik Kelas IV Mata Pelajaran Matematika Bangun Datar Dengan Pemanfaatan Media Interaktif Polypad, *Edukasi: Jurnal Penelitian dan Artikel Pendidikan*, 17(2). <https://doi.org/10.31603/edukasi.v17i2.14002>
- Octavia, R. (2022). Pengaruh Penerapan Model Pembelajaran Kooperatif Tipe STAD untuk Meningkatkan Motivasi Belajar dan Hasil Belajar Pecahan Matematika Kelas IV SD. *Jurnal Basicedu*, 6(2), 2904–2911. <https://doi.org/10.31004/basicedu.v6i2.2519>
- Okolie, U. C., Mlanga, S., Oyerinde, D. O., Olaniyi, N. O., & Chucks, M. E. (2022). Collaborative learning and student engagement in practical skills acquisition. *Innovations in Education and Teaching International*, 59(6), 669-678. <https://doi.org/10.1080/14703297.2021.1929395>
- Piaget, J. (1926). *The Language and Thought of Child*. London: Routledge
- Purwanto. (2013). *Evaluasi hasil belajar*. Yogyakarta: Pustaka Pelajar
- Putra, Z. H., Alim, J. A., Putri, R. R., & Melihayatri, N. (2025, November). Implementation of Polypad Media Based on Discovery Learning in Geometry Material in Elementary Schools. In *2025 3rd DMIHER International Conference on Artificial Intelligence in Healthcare, Education and Industry (IDICAIHEI)* (pp. 1-6). IEEE. <https://doi.org/10.1109/IDICAIHEI65991.2025.11378582>
- Rachmawati, D. N., Budi Iriawan, S., & Kurniawan, H. (2024). The application of the STAD cooperative learning model to improve Math learning outcomes. *Hipkin Journal of Educational Research*, 1(2). DOI: <https://doi.org/10.64014/hipkin-jer.v1i3.25>

- Rahman, A. (2025). The Effect of the Implementation of the Cooperative Learning Model Type Student Teams Achievement Division (STAD) on Creativity, Initiative, Motivation and Student Learning Outcomes. *Jurnal Iqra': Kajian Ilmu Pendidikan*, 10(1), 54-74. <https://doi.org/10.25217/ji.v10i1.5026>
- Ridayani, I., & Andriani, A. (2024). Peningkatan Prestasi Belajar Siswa Menggunakan Model STAD Berbantuan Media Geoboard Pada Pembelajaran Matematika SD. *JPPD: Jurnal Pedagogik Pendidikan Dasar*, 11, 134–141.
- Sahmat, S. D. R., & Dhoruri, A. (2024). The Influence of Learning Student Teams Achievement Division (STAD) on Students' Mathematical Learning Motivation. *Proceedings of the International Conference on Research in Education and Science*, 188–196. www.istes.orghttps://orcid.org/0009-0007-9515-5265
- Sartania, N., Sneddon, S., Boyle, J. G., McQuarrie, E., & de Koning, H. P. (2022). Increasing collaborative discussion in case-based learning improves student engagement and knowledge acquisition. *Medical science educator*, 32(5), 1055-1064. <https://doi.org/10.1007/s40670-022-01614-w>
- Slavin, R. E. (2015). Cooperative learning in elementary schools. *Education 3–13: International Journal of Primary, Elementary and Early Years Education*, 43(1), 5–14. <https://doi.org/10.1080/03004279.2015.963370>
- Suardiana, I. M. (2021). Penerapan Model Pembelajaran Kooperatif Tipe STAD untuk Meningkatkan Hasil Belajar Matematika. *Journal of Education Action Research*, 5(3), 381–386. <https://doi.org/10.23887/jear.v5i3.34677>
- Sudjana, N. (2016). *Penilaian hasil proses belajar-mengajar*. Bandung: PT Remaja Rosdakarya.
- Susanto, A. (2016). *Teori belajar dan pembelajaran di sekolah dasar*. Jakarta: Prenadamedia Group.
- Tessema, G., Michael, K., & Areaya, S. (2024). Realist Hands-On Learning Approach and Its Contributions to Learners' Conceptual Understanding and Problem-Solving Skills on Solid Geometry. *Pedagogical Research*, 9(1). <https://doi.org/10.29333/pr/14096>
- Wulandari, A., & Hasibuan, L. R. (2023). PENGARUH MODEL PEMBELAJARAN STAD DENGAN BANTUAN MEDIA GEOGEBRA TERHADAP HASIL BELAJAR MATEMATIKA SISWA SMP. *Jurnal Pembelajaran Matematika Inovatif*, 6, 641–650. <https://doi.org/10.22460/jpmi.v6i2.16264>
- Xu, C. (2025). Improving Mathematical Skills of Mathematics Education Students Through Integrated Use of Graphing Software and Programming Techniques. *International Journal of Education and Humanities*, 5(1), 13-24. <http://i-jeh.com/index.php/ijeh/article/view/277>